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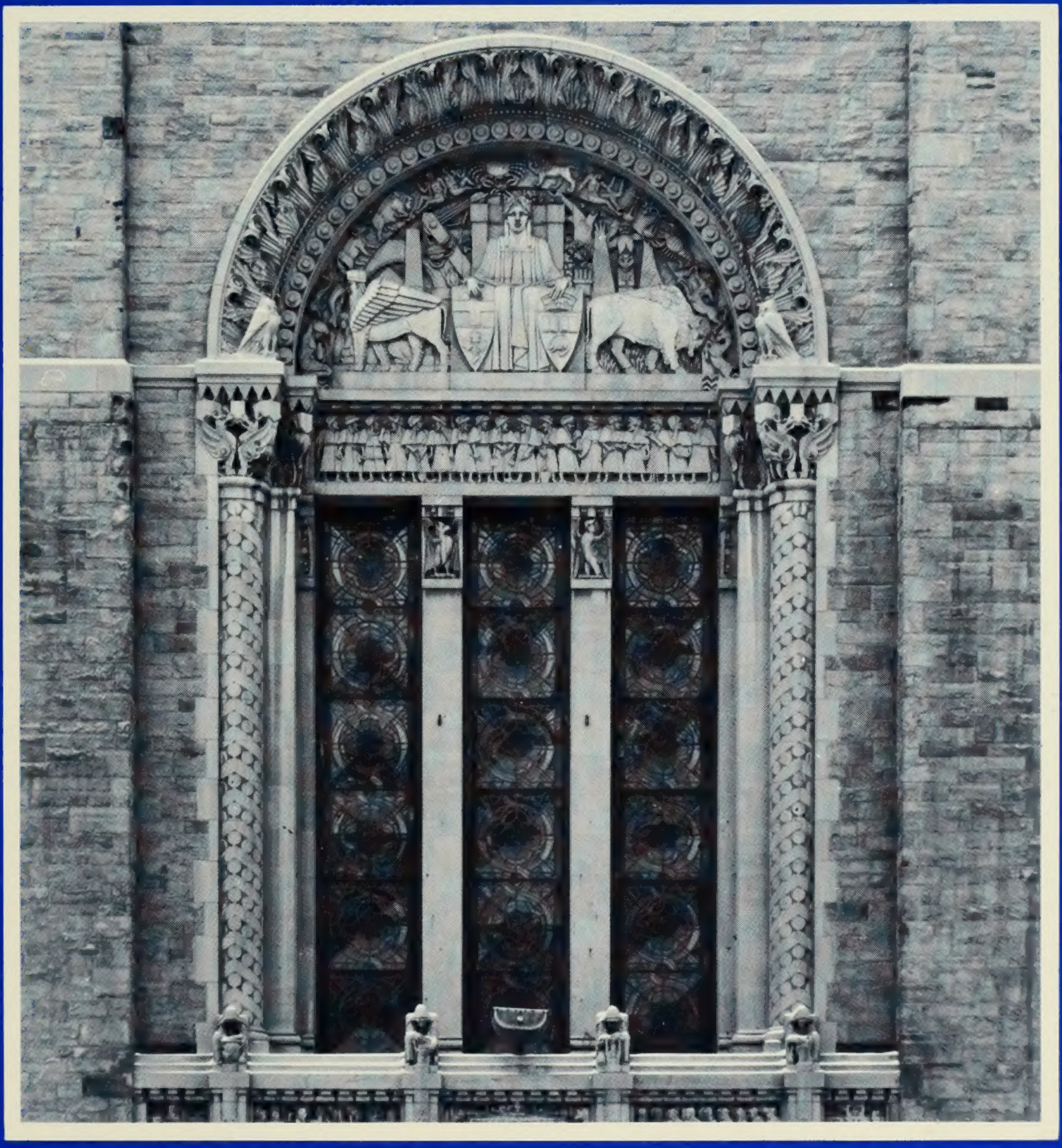

Biostratigraphy and Palaeontology of the Scollard Formation, Late Cretaceous and Paleocene of Alberta

Loris S. Russell

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Abstract

The Scollard Formation is the uppermost division of the Edmonton Group, exposed in the valley of Red Deer River, Alberta, north of Drumheller and east of Red Deer. The lower portion of the formation contains fossil vertebrates, including dinosaurs and mammals that correlate with those of the Lance Formation of Wyoming and the Hell Creek Formation of Montana. The highest stratigraphic occurrence of this fauna is at the Henry Farm locality, west of Content Bridge, where a wide range of vertebrates is represented by isolated teeth and bones. This occurrence is well below the Ardley coal seam. Above this seam is a shell bed containing a fauna of freshwater molluscs, ostracods, and fish remains. The molluscs correlate with those of the Paskapoo and other nonmarine Paleocene formations, but one species is known elsewhere only from Cretaceous deposits. This fauna is assigned to the early Paleocene. On the basis of the highest occurrence of dinosaur fossils, the Cretaceous-Tertiary boundary is taken to be about 11 m below the Ardley coal seam and about 20 m below the shell bed.

Introduction

The strata that make up the Scollard Formation were formerly known as the upper member of the Edmonton Formation. They include commercially important coal seams, but are most noted for containing within their sequence the Cretaceous-Tertiary, and hence Mesozoic-Cenozoic, boundary. The formation yields a variety of fossils, including those of mammals, reptiles, fishes, molluscs, ostracods, vascular plants, microspores, and pollen. Detailed study of the Scollard Formation should yield important data on the biological and physical conditions at this critical time in earth history.

With minor exceptions, exposures of the Scollard Formation are confined to the valley of the Red Deer River, between latitudes 51°45′ and 52°20′ north and longitudes 112°50′ and 115°25′ west. Scattered outcrops of the formation occur in uplands east of the Red Deer River. In southern Alberta the Willow Creek Formation represents an approximately equivalent time span, but lack of adequate exposures in the intervening area makes direct correlation of the two formations difficult.

Previous Work

The first geologist to examine the strata now known as the Scollard Formation was J. B. Tyrrell in 1884. In his report (Tyrrell, 1887) he mentioned the "big" (Ardley) coal seam, but was more concerned with the lower portions of the sequence; he designated the whole as the Edmonton Series, a name proposed earlier by Selwyn (1874).

Barnum Brown prospected a portion of the Red Deer River valley for fossil vertebrates in 1910, 1911, and 1912. Brown (1914b) recognized Tyrrell's stratigraphic subdivisions, the Edmonton and the Paskapoo, but did not distinguish the Scollard beds from other parts of the Edmonton "Formation." He did, however, collect dinosaur specimens from what are now known to be Scollard strata.

Subdivision of the Edmonton "Formation" began with the discovery by Sanderson (1931) of a widespread and distinctive bed of volcanic sediment that he named the Kneehills Tuff. This served as a stratigraphic boundary between the upper and the middle and lower portions of the Edmonton "Formation." Sternberg (1947, 1949), after some years of collecting, was able to establish that the dinosaurs of the "upper Edmonton member," above the Kneehills Tuff, represented a distinctive assemblage as

compared with those of the "middle" and "lower" Edmonton and could be correlated with the well-known Lance ("*Triceratops*") fauna of Wyoming. The distinction was formalized by Irish (1970), who designated the "lower" and "middle" Edmonton beds as the Horseshoe Canyon Formation, overlain by the Whitemud and Battle formations, extensions of the same formations in Saskatchewan. The Kneehills Tuff occurs near the top of the Battle Formation. Irish excluded the beds above the Battle Formation from the Edmonton Group and designated them the Scollard Member of the Paskapoo Formation. This arrangement was modified by Gibson (1977), who raised the Scollard to formational rank.

D. A. Russell and Chaitanya Singh (1978), on the basis of the dinosaur fauna and the microflora, concluded that the Cretaceous-Tertiary boundary occurred within the Scollard Formation, approximately at the Ardley coal seam. Their interpretation was modified by Lerbekmo et al. (1979), who placed the boundary lower, but still within the Scollard Formation. Evidence for a more precise allocation of the boundary within the formation is the principal subject of the present contribution.

Present Work

The specimens and data upon which the present contribution is based were obtained during eight field seasons (1976 to 1983), under the auspices of the National Research Council of Canada and the Natural Sciences and Engineering Research Council of Canada. Exposures in the valleys of the Red Deer River and its tributaries were examined and measured from the mouth of the Blindman River (legal subdivision 10, section 13, township 39, range 27, west of the 4th meridian) to the Tolman Bridge (ls. 15, sec. 14, tp 33, rge 22, W 4th M.). Special attention was given to the valley north and west of Ardley, and to the so-called Scollard Canyon, east of Huxley, since these are areas where Scollard beds are extensively exposed. Elevations were determined by stadia-compass survey or by altimeter, and stratigraphic sections were measured by Abney hand level, using either a surveyor's rod or a "Jacob's staff." Previously known fossil occurrences were located and new finds were exploited. In most cases large samples of the fossil beds were brought back to camp to be washed, disintegrated, screened to different grain sizes, and scanned under the binocular microscope. Preliminary identifications were made in the field, but final preparation and identification of the fossils were completed at the Royal Ontario Museum.

Biostratigraphy

SCOLLARD CANYON AREA (see Fig. 1)

As pointed out previously (Russell, 1983), there is a marked decrease in thickness of the lower Scollard beds between Scollard Canyon, east of Huxley, and various localities to the north, from McKenzie Crossing to the Henry Farm site and the Ardley area. Various explanations have been offered for this; the writer (Russell, 1983) has postulated an interval of nondeposition following accumulation of the Battle sediments and a progressively later deposition of the Scollard beds.

Many different kinds of fossils have been found in the Scollard Canyon area, most of which can be related accurately to the principal stratigraphic markers, the Kneehills Tuff below and the No. 14 coal seam above. What appears to be the lowest occurrence stratigraphically is the nearly complete skeleton of the small ornithopod dinosaur *Thescelosaurus edmontonensis* Sternberg (1940), which was found by C. M. Sternberg in 1925 on the east side of the Red Deer River valley, 3.5 km north of the present Tolman Bridge, east of Trochu. The site was relocated by Sternberg in 1946 and, according to his field notes, is 5 ft (1.5 m) above the Kneehills Tuff. A single mammal tooth found at this location was identified as the left lower molar of *Diaphorodon*? sp. (Russell, 1952). Following Clemens (1966:109), this would now be referred to *Didelphodon*? sp. The locality designated by Lillegraven (1969:12) as UA-2 is in the same general area and horizon; teeth of the mammals *Didelphodon vorax* Marsh, *Gypsonictops illuminatus* Lillegraven, *Cimolestes cerberoides* Lillegraven, and *Cimolestes magnus* Clemens have been described from here.

A little higher in the sequence is the site of the rich mammalian fauna at Griffith Farm, described in detail by Lillegraven (1969) under the designation KUA-1. It is on the east side of the river valley, 8 km north of Tolman Bridge (in ls. 2, sec. 18, tp 34, rge 21, W 4th M.). As noted by Lillegraven, the fossiliferous bed is about 43 ft (13 m) above the Kneehills Tuff. The latter here is about 1.5 m below the undulating Scollard-Battle contact. The mammalian assemblage here is a typical Lancian fauna, with all of the genera and some of the species also occurring in the type Lance Formation of eastern

Wyoming. All the species mentioned above as from locality UA-2 also occur at KUA-1.

Lillegraven (1969) mentioned a number of other fossil mammal localities in the vicinity of Griffith Farm. The highest he designated KUA-2, recording it as 89 ft (27 m) above the Kneehills Tuff. All the species that he reported from here are also listed by him from KUA-1 or equivalent strata.

Other important fossil occurrences in the Scollard Canyon area are on the west side of the Red Deer River valley. The incomplete skull of a ceratopsian dinosaur was collected in 1946 by Sternberg, as he records, about 55 ft (17 m) above the Kneehills Tuff (in 1s. 12, sec. 2, tp 34, rge 22, W 4th M.). It was subsequently described by Sternberg (1949) as *Triceratops albertensis*, n. sp. This was the first definite record of the Lancian "index" genus in the Scollard Formation. Just over a kilometre downstream from this site a large tributary valley enters the canyon from the northwest. This has been called Knudson Coulee (Russell, 1983). It was in this valley, in

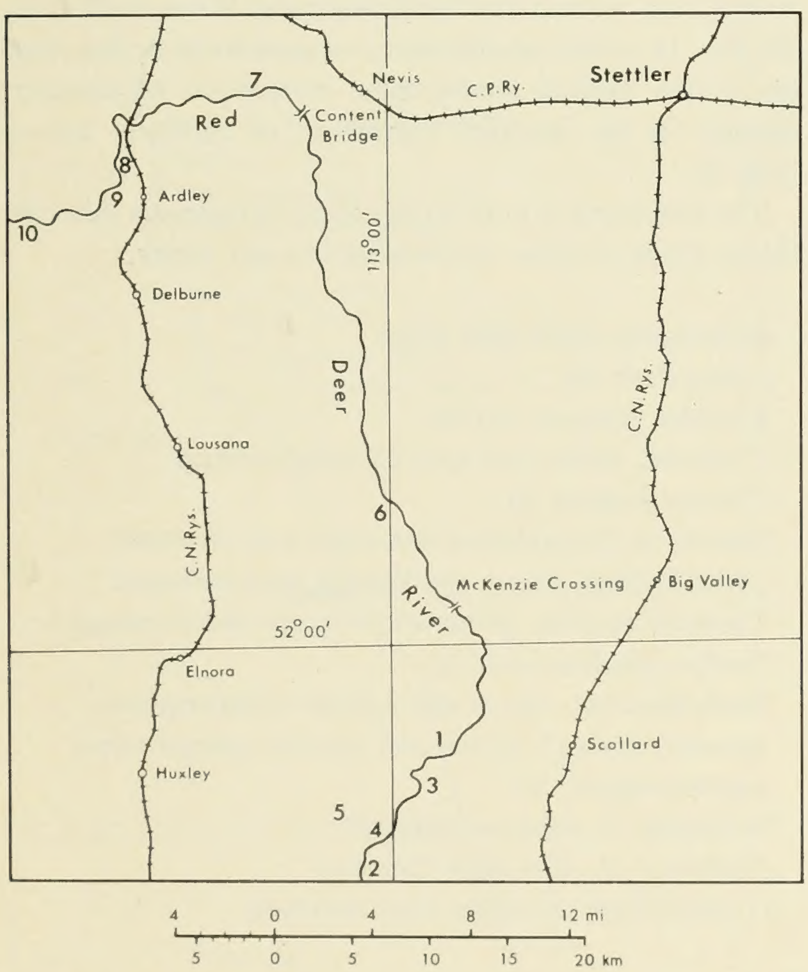

FIG. 1. Outline map of an area east of Red Deer, Alberta, showing locations of fossil occurrences mentioned in this paper. Numerals 1–10 indicate approximate position of the sites discussed: (1) Scollard Canyon; (2) *Thescelosaurus edmontonensis* Sternberg; (3) Griffith Farm; (4) *Triceratops albertensis* Sternberg; (5) Tyrannosaurid skeleton (Sternberg); (6) *Leptoceratops gracilis* Brown (Sternberg); (7) Henry Farm; (8) Lynass Mine; (9) Kirbyson Farm; (10) Getz Ranch.

1946, that Sternberg made several important discoveries. One of these was the poorly preserved skeleton of a large carnosaur, identified as *Tyrannosaurus* sp. Because of the scattered condition of the bones and the very hard matrix, Sternberg did not try to collect it, and it remained as a palaeontological monument until 1982, when it was taken up by a field party from the Tyrrell Museum of Palaeontology in Drumheller. Previously I had determined by stadia-compass survey that the bones in place were about 34 m above the Kneehills Tuff.

A few metres to the north Sternberg collected the occipital condyle and fragments of the crest of a ceratopsian dinosaur; D. A. Russell (*in* Russell and Singh, 1978) identified the species as *Triceratops albertensis* and stated that Sternberg placed it 20 ft (6 m) above the carnosaur. This would be the highest recorded stratigraphic occurrence of dinosaur remains in the Scollard Canyon area.

Sternberg also collected plant fossils from three localities in the upper end of Knudson Coulee. These were among the fossils used by Bell (1949:20) to recognize the "Upper Edmonton" flora as of Lancian age. The locality data as given by Bell (1949:84) differ from those in Sternberg's field notes and from my observations. The corrected data are as follows: 3679, NW $\frac{1}{4}$, sec. 10, tp 34, rge 22, W 4th M.; 3680, SW $\frac{1}{4}$, sec. 15, tp 34, rge 22, W 4th M.; 3681, SE $\frac{1}{4}$, sec. 16, tp 34, rge 22, W 4th M. The stratigraphic positions given in Sternberg's notes are 3680, 50–75 ft (15–23 m) above the tuff; 3681, 75 ft (23 m) above the tuff; 3679, "about 25 feet [8 m] below Ardley seam." The seam referred to is actually the Nevis or No. 13 seam, which is about 20 m below the Ardley (No. 14) seam. This would place plant locality 3679 at about 36 m above the Kneehills Tuff. It is the highest stratigraphic occurrence of "macro" plants in the lower (Lancian) Scollard beds. Bell (1949:60) identified *Platanus raynoldsii integrifolia* Lesquereux from here and regarded it as distinguishable from the Paleocene *P. raynoldsii* Newberry.

Barnum Brown made many important discoveries of fossil vertebrates in the Red Deer River valley from 1910 to 1912. Most of his finds were in strata well below the Scollard Formation; these strata were named the Horseshoe Canyon Formation by Irish (1970). However, Sternberg (1951:225) showed that two of Brown's dinosaur fossils were in "Upper Edmonton" (Scollard) beds. One of these consisted of the incomplete skeleton of a small ceratopsian, which Brown (1914a) named *Leptoceratops gracilis*. Sternberg was unable to locate Brown's discovery site, but from statements that it was "three miles [5 km] above Tolman Ferry" (Brown, 1914a:567) and about 190 ft (58 km) above the river (Brown, quoted by Sternberg, 1951:225), he was able to infer with confidence that it came from the "Upper

Edmonton member'' (probably from sec. 35, tp 33, rge 22, W 4th M.). The ''Upper Edmonton'' specimen collected by Brown consisted of bones and scutes of the armoured dinosaur *Anklyosaurus* sp. Sternberg (1951: 225) located the site 15 ft (4.5 m) above the Kneehills Tuff (in sec. 26, tp 33, rge 22, W 4th M.).

Prior to my fieldwork, the northernmost dinosaur fossils recorded from the Red Deer River valley were the three skeletons of the small ceratopsian *Leptoceratops gracilis* Brown, found by Sternberg in 1947 on the west side of the valley, 50 ft (15 m) above the Kneehills Tuff (in the northeast corner of sec. 12, tp 36, rge 22, W 4th M.) (Sternberg, 1951). This locality is immediately above the former Campkin (Thompson) coal mine and is now accessible from the Trenville Park campground. It is about 6 km north of McKenzie Crossing, where I measured the Scollard beds below the No. 14 coal seam as 34 m in thickness, in contrast to approximately 60 m in the Scollard Canyon (Russell, 1983:1224). The difference was explained as the result of an interval of nondeposition prior to the beginning of Scollard deposition. If this is so, intervals measured upwards from the Kneehills Tuff are not reliable indicators of relative stratigraphic position. In determining the stratigraphic position for dinosaur fossils within the Scollard Formation, it is better to measure down from the No. 14 seam. On this basis the Trenville Park *Leptoceratops* occurrence is 7 m higher stratigraphically than the highest dinosaur provenience in Knudson Coulee.

Before leaving consideration of the fossil occurrences in the Scollard Canyon area, reference should be made to the palynological findings. Snead (1969:15–22) recognized two ''zones'' of microspores and pollen, the lower (A) ranging from ''just below the Kneehills Member'' to ''the base of the upper coal interval'' (i.e., the Ardley seam), the upper (B) from ''the uppermost beds of the Edmonton (upper coaly interval),'' that is, from the base of the Ardley seam to the contact with the Paskapoo Formation. Snead's microfloral ''zone'' B, therefore, represents what I am calling the upper Scollard beds. Snead concluded that the Cretaceous-Tertiary boundary occurs somewhere within ''zone'' B.

Srivastava (1970) recognized nine pollen-assemblage zones in the Edmonton Group, from the base to just above the Nevis coal seam. His Zone VIII (*Wodehouseia spinata* Stanley Zone) extends from the Battle Formation to the Nevis seam in the Scollard Formation, and his Zone IX (*Wodehouseia fimbriata* Stanley Zone) begins at the top of the Nevis seam. The zone fossil *W. fimbriata* has Paleocene affinities. Singh (*in* Russell and Singh, 1978) confirmed Srivastava's findings, but temporarily misidentified the coal seam above the dinosaurs in Knudson Coulee as the Ardley rather than the Nevis seam. This was corrected subsequently by Lerbekmo, and the distribution of *Wodehouseia spinata* below and of *W. fimbriata* above the Nevis seam was confirmed by Singh and Jarzen (*in* Lerbekmo et al., 1979), who proposed that the Nevis seam, or the associated microfloral break, be taken to mark the Cretaceous-Tertiary boundary.

HENRY FARM LOCALITY (see Figs. 1 and 2)

Dinosaur remains in what is apparently a higher stratigraphic position than those of the Scollard Canyon area have been found at the Henry Farm locality, 3 km west of Content Bridge. This occurrence, discovered by Mrs Russell and me in 1979, is located on the north side of the Red Deer River valley (in ls. 8, sec. 5, tp 39, rge 22, W 4th M.). A descriptive section and a graphic representation of the sequence has been published (Russell, 1983). The highest stratigraphic level at which dinosaur remains were found was originally recorded as 6.4 m above the Scollard-Battle contact, or about 10 m above the Kneehills Tuff. More recent examination of the residues has revealed a fragmentary dinosaur tooth from about 12 m above the tuff. This works out to be about 11 m below the Ardley coal seam in the local sequence. If the Ardley and the No. 14 seams are the same, as appears to be the case, this is the highest stratigraphic occurrence of dinosaur remains in the Scollard Formation as currently known (Fig. 2).

The following is a list of the fossil vertebrates from the Henry Farm locality, as identified by the writer.

Myledaphus bipartitus Cope
Lepisosteus sp.
Kindleia fragosa Jordan
Chelonia, genus and species undetermined
Champsosaurus sp.
Sauria, cf. *Parasaniwa wyomingensis* Gilmore
Crocodylidae, genus and species undetermined
Tyrannosauridae, genus and species undetermined
Pachycephalosaurus? sp.
Hadrosauridae, genus and species undetermined
Iguanodontidae?, genus and species undetermined
Leptoceratops? sp.
Mesodma cf. *formosa* (Marsh)
Pediomys cf. *florencae* Clemens
Gypsonictops cf. *hypoconus* Simpson

This vertebrate assemblage is in most respects typically late Cretaceous. The incomplete and fragmentary nature of the specimens tends to restrict the identification to the generic or higher levels, and this makes it difficult to differentiate the fauna from that of other localities and horizons. With two exceptions, however, there is no aspect that is incompatible with the age as determined stratigraphically, that is, Lancian or latest Cretaceous.

One of the anomalies is the apparent absence of large ceratopsian teeth, such as would represent the characteristic Lancian genus *Triceratops*. This genus is recorded from lower levels in the Scollard Formation; its absence at Henry Farm might be fortuitous, but might reflect the extinction of the larger ceratopsians earlier than the extinction of some other dinosaurs.

The other anomaly in the Henry Farm fauna is the apparent presence of an iguanodont dinosaur, representing a group not previously reported from North America. Two interpretations are possible. Either this occurrence represents an independent development in North America in late Cretaceous time of an iguanodont-like ornithopod, or it may indicate a hitherto undetected immigrant and survivor from earlier Cretaceous time. Neither interpretation seems very convincing at present.

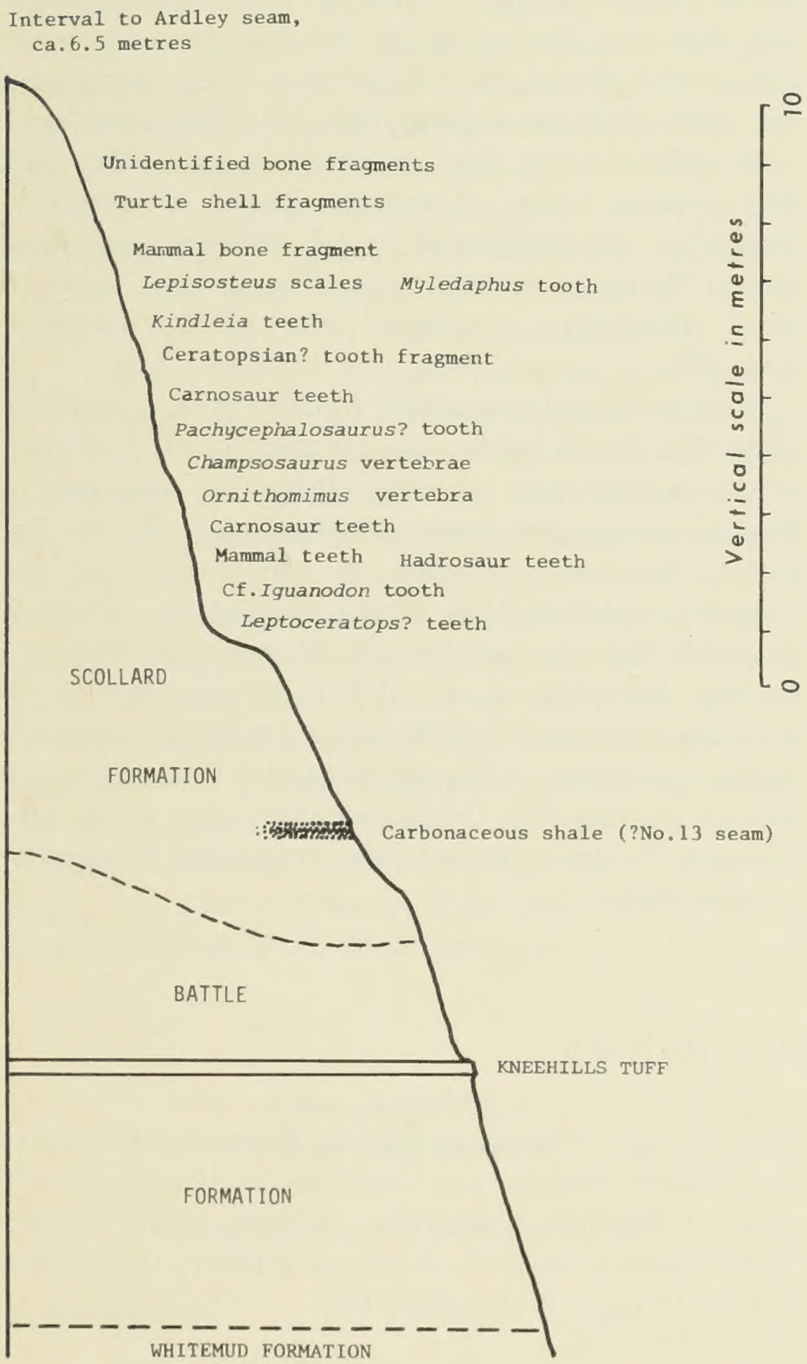

FIG. 2. Diagrammatic columnar section of Henry Farm locality (in legal subdivision 8, section 5, township 39, range 22, W 4th meridian), north side of Red Deer River valley, showing stratigraphic position of various fossils.

Comparing the Henry Farm vertebrate fauna with that of the Paskapoo and other Paleocene formations, there is nothing in the former that would support a post-Cretaceous dating. The Henry Farm fauna appears to be one of the youngest Cretaceous vertebrate assemblages so far discovered, but it is nevertheless unmistakably Cretaceous.

In view of the importance attached to the microflora found in the Scollard Canyon area by Snead and Srivastava, samples of shale were collected at various levels in the Henry Farm section for palynological analysis. These samples were prepared in the Department of Geology, University of Toronto, and examined by Dr G. Norris. His tentative findings (pers. comm.) are that *Wodehouseia spinata* Stanley, *Aquilapollenites* sp., and *Azolla* sp. occur in the sample taken from 5 m above the Scollard base, and possibly *Kurtzipites* sp. or *Aquilapollenites* sp. about 11 m above the base. This accords with the occurrence of *W. spinata* in the dinosaur-bearing part of the Scollard Formation in the Scollard Canyon area, as noted above.

ARDLEY AREA (see Fig. 1)

At Henry Farm the Ardley coal seam is at prairie level. The seam dips to the west at about 2.5 m/km, and in the Sisson mine, about 10 km to the west (in ls. 15, sec. 33, tp 38, rge 23, W 4th M.), it is approximately 17 m lower topographically. Because of the importance of this seam as a stratigraphic marker, a detailed section of the coal and associated beds exposed in the mine is here recorded.

Shale and sandy shale	+ 5.0 m
Ironstone concretions, flat, intermittent	± 0.1 m
Shale and sandy shale	5.5 m
Ironstone concretions, flat, intermittent	± 0.1 m
Shale and sandy shale, with shaly coal	1.5 m
Coal	2.8 m
Bentonite, soft, greenish grey	0.4 m
Coal	1.0 m

Some, but not all, of the ironstone concretions in both layers have cleavage planes with numerous leaf impressions. Among the dicotyledonous genera that appear to be represented are *Platanus* and *Viburnum*. Because of the proximity of this plant occurrence to the Cretaceous-Tertiary boundary, an adequate collection should be made and studied.

A large exposure of Scollard beds, with the Ardley coal seam, occurs at "Horseshoe Bend" on the north side of the Red Deer River (in ls. 12, sec. 32, tp 38, rge 23, W 4th M.). No fossils have been found here as yet.

Farther south, the uppermost beds of the Scollard Formation and the contact with the Paskapoo sandstone are exposed on the east rim of the valley (in ls. 2, sec. 29, tp 38, rge 23, W 4th M.). Farther south still (in sec. 20), there is a series of abandoned open-pit coal mines. I shall refer to these as the Lynass Mine, from the name of the landowner. In one of these pits (in ls. 7), there is an extended exposure of about 12 m of shale, sandstone, and thin coal seams overlying the Ardley seam. At about 6 m above the top of the Ardley seam there is a bed of carbonaceous shale containing numerous crushed mollusc shells. For the present purposes I shall call this the Ardley shell bed. What appears to be the same bed occurs in the large cliff on the southeast side of the valley (in ls. 8, sec. 17, tp 38, rge 23, W 4th M.). Here a continuous section is exposed from the Paskapoo sandstone to the Ardley coal seam, a vertical interval of about 34 m. At approximately 6 m above the seam, the shell bed occurs in sandy shale. For convenience this location is here referred to as the Kirbyson Farm locality, named after the landowner. Presumably this is the shell bed referred to by Sanderson (Allan and Sanderson, 1945, pl. II, sec. D). The third occurrence of the shell bed is to the west in a small, obscure exposure on the south bank of the river (in ls. 2, sec. 9, tp 38, rge 24, W 4th M.). Unfortunately, neither the Ardley seam nor the Paskapoo sandstone is exposed here to confirm the stratigraphic position. The presence of a small coal seam about 4.3 m above the shell bed is similar to the situation at Lynass Mine, where there is a small coal seam about 4 m above the shell bed. I shall refer to this third occurrence of the shell bed as the Getz Ranch locality.

The following is a composite list of the molluscan fauna obtained from the three exposures of the Ardley shell bed.

Plesielliptio cf. *priscus* (Meek and Hayden)
Sphaerium formosum (Meek and Hayden)
Sphaerium fowleri Russell
Pisidium squamula Russell
Hydrobia anthonyi (Meek and Hayden)
Hydrobia warrenana (Meek and Hayden)
Valvata subumbilicata (Meek and Hayden)
Viviparus leai (Meek and Hayden)
Lioplacodes nebrascensis (Meek and Hayden)
Lioplacodes tenuicarinata (Meek and Hayden)

The molluscan fauna listed above strongly resembles that of the Paskapoo and equivalent Paleocene formations. Correlation based on this resemblance is open to the objection that a comparable fauna of freshwater molluscs is not known from undoubted Cretaceous formations in this area. Farther south in Alberta, the St Mary River Formation, of late Cretaceous age, has a molluscan fauna with an ecology similar to that of the Ardley molluscs. However, there is only one species, *Pisidium squamula*, that is common to the St Mary River and Ardley faunas and does not also occur in the Paskapoo Formation (Paleocene). Hence the evidence for a Paleocene age for the Ardley shell bed is greater than for a Cretaceous age.

In addition to the shells of molluscs, the Ardley shell bed contains valves of several species of ostracods. Vertebrates are represented by fish vertebrae, teeth, and scales. The scales include those of *Lepisosteus* sp. and a small rectangular, ornamental scale not yet identified (Fig. 6F).

A palynological preparation from the Ardley shell bed at the Getz Ranch locality was examined by Dr G. Norris, who reported (pers. comm., 1983) the presence of *Wodehouseia spinata* Stanley and *Aquilapollenites* sp. The former has been regarded as characteristic of the Cretaceous portion of the Scollard Formation, as distinct from the Paleocene portion with *Wodehouseia fimbriata* Stanley (Lerbekmo et al., 1979). But the Getz Ranch occurrence lies more than 22 m stratigraphically above the highest occurrence of dinosaur remains at Henry Farm and about 6 m above the Ardley coal seam. One would have expected *Wodehouseia fimbriata*, rather than *W. spinata*, to occur here.

Systematic Palaeontology

Unless otherwise indicated, the specimens described in this section are preserved in the Royal Ontario Museum, Department of Vertebrate Palaeontology and Department of Invertebrate Palaeontology, Toronto, Ontario. The exceptions are designated by the following abbreviations: GSC, Geological Survey of Canada, Palaeontology collection, Ottawa, Ontario; UA, University of Alberta, Department of Geology, Edmonton, Alberta; USNM, United States National Museum of Natural History, Department of Paleobiology, Washington, D.C.

Phylum Chordata
Class Chondrichthyes
Order Rajiformes
Family Dasyatidae

Genus *Myledaphus* Cope, 1876

Myledaphus bipartitus **Cope, 1876**

REFERRED SPECIMENS

Numerous isolated teeth, from up to 10 m above the base of the Scollard Formation, Henry Farm locality (Fig. 3A,B).

REMARKS

The characteristic pavement teeth of this ray were described by Cope (1876:26) from the Judith River Formation of Montana. In Alberta they occur in the Upper Milk River beds, the Oldman Formation, the Horseshoe Canyon Formation, and the Scollard Formation. They are especially abundant in the basal beds of the St Mary River Formation at Scabby Butte (Langston, 1976). Cope's description was so lucid that an illustration was hardly necessary, but good figures were published by Lambe (1902, pl. 19, figs. 1,2) and by Russell (1935, pl. 2, fig. 1). Estes (1964:15–19) gave a detailed description of *Myledaphus* teeth from the Lance Formation of Wyoming, with illustrations of the variations and a discussion of the relationships. He concluded that *Myledaphus* was a dasyatid ray, related to the living *Hypolophus*. A specimen showing what may be the cartilaginous skeleton has been described by Langston (1970) from the Oldman Formation. At Henry Farm locality *Myledaphus* teeth occur at various levels up to 10 m above the base of the Scollard Formation. A different sort of tooth, from 9 m above the base, has a crown that is triangular in outline, angulate on one side, rounded on the other. The grinding surface is irregularly crenulate, not striate. The root is long and single, with a notch at the tip. This tooth might be from a marginal portion of the dental pavement.

Class Osteichthyes
Family Lepisosteidae

Genus *Lepisosteus* Lacépède, 1803

Lepisosteus **sp.**

REFERRED SPECIMENS

Incomplete opercular; numerous scales, from up to 7 m above the base of the Scollard Formation, Henry Farm locality (Fig. 3C).

REMARKS

The familiar rhomboid scales of the garpike are common at the Henry Farm locality, especially in the lower part of the sequence. Most of these are relatively small. The external enamel is smooth, except for two or three small, shallow pits near the centre. Similar scales are known from the Upper Milk River beds of Alberta (Russell, 1935, pl. 2, fig. 2) and on up through the stratigraphic column to the Ravenscrag Formation (Paleocene) of Saskatchewan (Russell, 1974, fig. 5).

Family Amiidae

Genus *Kindleia* Jordan, 1927

***Kindleia*? sp.**

REFERRED SPECIMENS

Jaw fragments and palatal teeth, from up to 9 m above the base of the Scollard Formation, Henry Farm locality (Fig. 3D–F).

REMARKS

Bones and teeth of an amiid fish were first described from the Scollard Formation by D. S. Jordan (1927) under the name of *Kindleia fragosa*, and assigned to the Cichlidae. Shortly afterwards I described what is presumed to be the same fish from the Paskapoo Formation (Paleocene), which I named *Stylomyleodon lacus* and referred to the Amiidae (Russell, 1928). Some years later Estes (1964:29–41) described cranial bones from the Lance Formation of Wyoming, which he referred to *Kindleia fragosa*. Subsequently Janot (1967) reviewed a number of fossil amiids from the Tertiary of Europe and assigned *Kindleia* and other North American genera to *Amia*. In this she was followed by Estes and Berberian (1969), who nevertheless listed a number of features in which *Kindleia* differs from *Amia*. To these could be added the bulbous, rather than pointed, palatal teeth of *Kindleia* which, together with the other differences listed by Estes and Berberian, might seem to justify a generic separation. Gaudant (1980) classed *Kindleia* as a subgenus of *Amia*, including in it both *K. fragosa* and *Amia kehreri*. In a recent visit to Toronto, Dr Gaudant informed me that *Kindleia* is a junior synonym of *Notaeus* Agassiz (1844:127, pl. 46) from the Eocene of France. While awaiting further clarification of the nomenclature, I shall use Jordan's name for this widely distributed amiid.

The distinctive palatal teeth of *Kindleia* (Fig. 3E), which are like tiny pillars terminating in a globular head (crown), are close set in the jaw bones and almost form a pavement. They have been found in the Cretaceous Lance Formation of Wyoming, Hell Creek Formation of Mon-

tana, and Scollard Formation of Alberta, and in the Paleocene Ravenscrag Formation of Saskatchewan and Paskapoo Formation of Alberta.

Two jaw fragments from about 5 m above the Scollard base at Henry Farm are referred to *Kindleia fragosa*. On both fragments the teeth have been broken away, leaving basined rims. One fragment (Fig. 3D) is presumed to be part of the right maxilla. On this the tooth remnants are ovoid, compressed anteroposteriorly. On the other fragment, a portion of the dentary, the tooth remnants are circular and more widely spaced.

In most of the assemblages in which the characteristic palatal teeth of *Kindleia* occur, there are also present rectangular ''ganoid'' scales very unlike the cycloid scales of typical amiids. On the remote possibility that the association might be a natural one, these scales from the Henry Farm locality are here provisionally included under *Kindleia*? sp. A typical example is illustrated (Fig. 3F); it is from about 5 m above the formational base. Dimensions of this specimen are as follows: height, 8.1 mm; width, 4.2 mm.

Class Reptilia
Order Chelonia

Genus and species undetermined

REFERRED SPECIMENS

Numerous fragments of carapace and plastron, from up to 11 m above the base of the Scollard Formation, Henry Farm locality.

REMARKS

Some of these turtle-shell fragments show the characteristic trionychid sculpture on the external surface, others are quite smooth. Apart from this they have little on which to base an identification.

Order Eosuchia
Family Champsosauridae

Genus *Champsosaurus* Cope, 1876

***Champsosaurus* sp.**

REFERRED SPECIMENS

Several vertebral centra, from up to 6 m above the base of the Scollard Formation, Henry Farm locality (Fig. 3G,H).

REMARKS

A typical vertebral centrum of this eosuchian is amphiplatyan, with a narrow channel for the neural canal, and a pair of triangular facets on which the lower ends of the neural arch rested but did not fuse. Such vertebral centra occur in a number of nonmarine formations in western North America, ranging from the Milk River Formation (Cretaceous) of Alberta to the basal Willwood beds (Lower Eocene) of Wyoming.

Order Sauria
Family Varanidae

Genus *Parasaniwa* Gilmore, 1928

Cf. *Parasaniwa wyomingensis* Gilmore, 1928

REFERRED SPECIMEN

A small mandibular fragment with two teeth, from about 7 m above the base of the Scollard Formation, Henry Farm locality (Fig. 3I).

FIG. 3A–N. Fossils from Henry Farm locality.
A. *Myledaphus*? sp., tooth, crown view, × 6.5.
B. Same, lateral view, × 6.5.
C. *Lepisosteus* sp., flank scale, external view, × 6.5.
D. *Kindleia*? sp., right maxillary fragment, × 4.5.
E. *Kindleia*? sp., palatal tooth, lateral view, × 4.5.
F. *Kindleia*? sp., scale, internal view, × 4.5.
G. *Champsosaurus* sp., vertebral centrum, anterior view, × 2.
H. Same, dorsal view, × 2.
I. Cf. *Parasaniwa wyomingensis* Gilmore, stereoscopic internal views of mandibular fragment, × 6.
J. Crocodylid, caudal vertebra, lateral view, × 2.
K. Same, anterior view, × 2.
L. Tyrannosaurid, tooth, lateral view, × 2.
M. Tyrannosaurid, tooth fragment, lateral view, × 2.
N. Unidentified theropod tooth, lateral view, × 3.

Fig. 3

REMARKS
A lizard appears to be represented at the Henry Farm locality by this one specimen. The teeth evidently have been shortened by wear and were probably pointed when complete. They now terminate in an anteroposterior edge and are compressed transversely. The surface of the teeth is striate vertically, especially on the lower part. Basally the teeth arise from the dentary bone, just external to a longitudinal ridge. They are subpleurodont, with the dorsal rim of the dentary rising higher on the external side of the teeth than on the internal side. Allowing for the imperfect preservation, this fragment suggests the dentary of *Parasaniwa wyomingensis*, as described and figured by Gilmore (1928:85, 86) and by Estes (1964:129), from the Lance Formation of Wyoming.

Order Crocodilia
Family Crocodylidae

Genus and species undetermined

REFERRED SPECIMENS
Several small teeth, from up to 7 m above the base of the Scollard Formation; one caudal vertebra, from 6 m above the formational base (Fig. 3J,K).

REMARKS
The teeth are referred to the Crocodilia because of their pointed, conoid shape and their vertical striations and transverse colour banding. One tooth is very short and broad, evidently from the posterior part of the dentition. On the vertebra the centrum is long anteroposteriorly and compressed transversely. The anterior face is slightly concave, the posterior distinctly convex. The neural spine is directed vertically; it is thick in front but contracts posteriorly to a thin edge, which terminates on the rim of the neural canal. Both sets of zygopophyses are slightly damaged. The narrow ventral surface of the centrum bears a shallow groove for its full length, bounded by two low ridges. Length of the centrum is 22 mm.

The common crocodilian genus in the Upper Cretaceous of western North America is *Leidyosuchus* Lambe (1908), to which the Henry Farm material might belong.

Order Saurischia
Family Tyrannosauridae

Genus and species undetermined

REFERRED SPECIMENS
Teeth and tooth fragments, from up to 8 m above the base of the Scollard Formation, Henry Farm locality (Fig. 3L–N).

REMARKS
These teeth show the recurved blade with finely serrated front and back edges typical of the tyrannosaurids ("deinodontids"), but they are much smaller than the teeth of *Tyrannosaurus* or even of the smaller and earlier *Albertosaurus*. The size suggests the small theropod *Dromaeosaurus* Matthew and Brown (1922). However, in *Dromaeosaurus* the apical third of the tooth is more strongly recurved than the more basal two-thirds, whereas in the Henry Farm teeth the curvature is regular. An even smaller theropod is represented by a tooth (Fig. 3N) from about 5 m above the formational base. This tooth is very slender and thin and only slightly recurved, the posterior margin being almost straight. Both edges are serrate, the posterior more coarsely than the anterior. Height of this tooth, as preserved, is 7.1 mm.

Order Ornithischia
Family Pachycephalosauridae

Genus *Pachycephalosaurus* Brown and Schlaikjer, 1943

Pachycephalosaurus? sp.

REFERRED SPECIMEN
Well-preserved tooth, from about 7 m above the base of the Scollard Formation, Henry Farm locality (Fig. 4A,B).

DESCRIPTION
The tooth consists of the complete crown and most of the root. For descriptive purposes it is assumed to be from the right maxilla, well back in the dental series. The crown is symmetrically triangular in side view, the apex directed ventrad, and the base of the triangle bilobate. The external face of the crown is convex vertically and anteroposteriorly and strongly sculptured with vertical ridges. The median ridge is robust and straight, but gives rise near its apex to anterior and posterior branch ridges. There are four distinct ridges anterior to the median ridge and five posterior to it. All curve away from the median ridge. The anteriormost and the posteriormost ridges are very small. The inner face of the crown is convex anteroposteriorly but slightly concave vertically. The ridge pattern on the inner face is a mirror image of that on the outer face, but the ridges are not so prominent. The cutting edge of the crown is strongly denticulate, each denticle being the termination of a vertical ridge. The points, except for that of the median denticle, are extended by a thin flange on the side facing away from the median denticle. The surface of the enamel is finely crenulate. Height of the crown is 4.9 mm, and the anteroposterior width is 4.2 mm.

REMARKS

Teeth of this sort were first described by Gilmore (1924) from the fine skull and mandible at the University of Alberta. This skull incorporates the greatly thickened frontoparietal roof, a feature that was described by Lambe (1902) under the name of *Stegoceras validus*. On the basis of the perceived resemblance between the premaxillary teeth of the University of Alberta skull and the tooth described by Leidy (1856) as *Troödon formosus*, from the Judith River Formation, Gilmore classed *Stegoceras* as a junior synomyn of *Troodon*. This decision was accepted by Brown and Schlaikjer (1943) when they described the grotesque relative from the Hell Creek Formation under the name of *Pachycephalosaurus grangeri*. However, Sternberg (1945) and Russell (1948) showed that the type of tooth described by Leidy as *Troodon* was very different from those of the University of Alberta skull and actually represented the tooth of a small theropod dinosaur. The generic name *Stegoceras* was revived for the so-called dome-headed dinosaur and placed with *Pachycephalosaurus* in the newly proposed family Pachycephalosauridae (Sternberg, 1945).

The tooth from the Henry Farm locality is assigned provisionally to *Pachycephalosaurus* because of the strong ribbing of the crown faces, both the inner and the outer. The known stratigraphic distribution of *Stegoceras* (Judithian, Edmontonian) and *Pachycephalosaurus* (Lancian) makes the reference to the latter genus more plausible.

Family Hadrosauridae

Genus and species undetermined

REFERRED SPECIMENS

Tooth fragments, from up to 6 m above the base of the Scollard Formation, Henry Farm locality.

REMARKS

Remains of hadrosaurian dinosaurs are surprisingly rare in the Henry Farm assemblage. However, these tooth fragments identified as hadrosaurid show clearly the symmetrical enamel face and the median ridge. The fragments appear to pertain to robust teeth, more like those of the hadrosaurines than those of the lambeosaurines.

Family Iguanodontidae?

Genus and species undetermined

REFERRED SPECIMEN

An incomplete tooth, from about 5 m above the base of the Scollard Formation, Henry Farm locality (Fig. 4C–E).

DESCRIPTION

This tooth is assumed to be from the mandibular series because of the strong curvature. It is slightly waterworn and is truncated by premortem wear at the upper end, but it still shows the essential features. The crown is relatively broad compared with the crowns of hadrosaur teeth. The external face is bordered by marginal ridges, which define a slightly asymmetrical, V-shaped enamel face. Within the boundaries of this face is another pair of converging ridges, defining a smaller V-shaped area. This is in strong contrast to the straight median ridge characteristic of hadrosaur teeth. The inner side of the tooth has a deep vertical groove, which extends from the upper limit of the crown to the tip of the root. This groove is bounded by strong ridges, which in their upper part are formed of enamel. The worn grinding surface of the crown shows three areas of radially striate enamel, one formed by the outer face of the crown, the other two by the ridges of the inner side. The root is long, constricted as compared with the crown, and terminates in a rounded tip. Height of the tooth, as preserved, is 33 mm, and the anteroposterior width is 13 mm.

REMARKS

This tooth is unlike that of any Late Cretaceous ornithopod with which I am familiar, but it shows a striking resemblance to some teeth of *Iguanodon*, from the Lower Cretaceous of England and Belgium (see Owen, 1854:30, 31, pl. 18). Like some teeth of *Iguanodon*, this specimen has a relatively broad crown, a long, tapering root, and a nearly flat outer surface of the crown, with two vertical ridges. The Scollard tooth differs in having a deep internal groove and nondenticulate marginal ridges on the crown. Denticulate margins may have been present on the portion of the tooth that has been removed by premortem wear.

The wide separation in time and space between the Wealden iguanodonts of Europe and the species represented by the Scollard tooth from Alberta makes close relationship seem improbable. However, D. A. Russell informed me (pers. comm., 1984) that similar teeth occur in the Hell Creek Formation of Montana. A cast he provided of one of these teeth includes the part that is missing from the Scollard tooth, and the composite reconstruction based on the two teeth shows a striking resemblance to some of Owen's (1854) illustrations.

Family Protoceratopsidae

Genus *Leptoceratops* Brown, 1914

Leptoceratops? **sp.**

REFERRED SPECIMENS

Two small teeth (Fig. 4F–H), from 6 m and 5 m,

respectively, above the base of the Scollard Formation, Henry Farm locality.

DESCRIPTION

The specimen (Fig. 4F) from the 6-m level is the upper half of a tooth that appears to be ceratopsian but is relatively narrow and shows no evidence of a secondary root. The enamel (external) face is nearly flat, tapering to a blunt point above, and has three vertical ridges, one on each margin, and one low, narrow median ridge. None of these ridges is serrate. The internal side of the tooth is strongly convex. Anteroposterior width is 10.8 mm, and transverse width is 7.0 mm.

The tooth from the 5-m level (Fig. 4G,H) is even smaller. The crown is broad anteroposteriorly, thin transversely, and low. The cutting edge of the crown is broadly angulate, forming an obtuse apex, and is denticulate, each denticle continuing up the outer and inner faces of the crown as a narrow ridge, almost to the base of the enamel. There are seven denticles and ridges on each side of the median ridge; the median ridge is wider than the other ridges, but is low and rounded on the outer face and indistinct on the inner. The root is an extension of the crown, not a distinct stem as in the superficially similar ankylosaur teeth. In side view the tooth narrows downwards, but in anterior or posterior view it expands inwards. There is an incipient secondary root, which is partly broken away; this partial separation is emphasized by a deep excavation into one edge of the main root and by a smaller groove in the median portion of that main root. The outer edge of the main root shows no separation. Anteroposterior width of the crown is 9.2 mm and transverse width is 3.7 mm.

REMARKS

The tooth from the 6-m level bears some resemblance to the mandibular teeth of *Leptoceratops gracilis* as described and illustrated by Brown (1914a:569, fig. 6). Both have a single root and a convex inner side. The Scollard tooth differs in having more slender proportions and a weaker median ridge on the enamel face.

The tooth from the 5-m level suggests the maxillary tooth illustrated by Brown (1914a, fig. 2) from *Leptoceratops gracilis*, but the crown is much lower and the apical angle much more obtuse. Teeth similar to this specimen occur in the Oldman Formation, especially in the Comrey district of southeastern Alberta. Some of these show an incipient secondary root, which is absent on the Scollard tooth.

Class Mammalia
Order Multituberculata
Family Neoplagiaulacidae Ameghino, 1918

Genus *Mesodma* Jepsen, 1940

***Mesodma* cf. *formosa* (Marsh), 1889**

REFERRED SPECIMENS

Left P^4, lacking posterior third (Fig. 4I); left P_4, lacking posterior half (Fig. 4J); from about 6 m above the base of the Scollard Formation, Henry Farm locality.

DESCRIPTION

On the P^4, four cusps of the median row are preserved; these have about the same height from front to rear. The anteroexternal cusps are three in number, the third being aligned with the gap between the third and fourth median cusps; the row of anteroexternal cusps diverges obliquely from the line of median cusps towards the base of the crown. The boundary between crown and root dips at the anteroexternal corner. Maximum width of tooth at anterior end is 1.2 mm; this width is within the size range for P^4 in *M. formosa* as given by Clemens (1963:38).

On the P_4, three external ridges are present; they are short and of about equal length. The marginal serrations have been worn away, leaving an apical groove, but the outline of the cutting edge was evidently moderately high and arcuate. The anterior margin of the crown is nearly straight and is inclined away from the anterior margin of the root; it is bevelled from lingual side to labial side, but

FIG. 4A–J. Fossils from Henry Farm locality.
A. *Pachycephalosaurus*? sp., presumed maxillary tooth, external view, × 6.
B. Same, internal view, × 6.
C. Iguanodont?, mandibular tooth, external view, × 2.
D. Same, internal view, × 2.
E. Same, posterior? view, × 2.
F. *Leptoceratops*? sp., incomplete tooth, external view, × 2.
G. *Leptoceratops*? sp., maxillary? tooth, external view, × 4.
H. Same, internal view, × 4.
I. *Mesodma* cf. *formosa* (Marsh), incomplete left P^4, stereoscopic external views, × 10.
J. *Mesodma* cf. *formosa* (Marsh), incomplete right P_4, stereoscopic internal views, × 10.

Fig. 4

this may be due to wear, since the anterobasal overhang for P_3 is gone as well. Width of the crown at the anterior is 1.5 mm; this width is within the size range for P_4 in *M. formosa* (Clemens, 1963:38).

Order Marsupialia
Family Pediomyidae Clemens, 1966

Genus *Pediomys* Marsh, 1889

Pediomys cf. *florencae* Clemens, 1966

REFERRED SPECIMEN

The talonid of a right M_1 or M_2 (Fig. 5A), probably the latter, from about 6 m above the base of the Scollard Formation, Henry Farm locality.

DESCRIPTION

The trigonid has been broken away along the base of the posterior wall. The remnant indicates that it was narrower than the talonid, hence the identification as M_1 or M_2. The cristid obliqua is directed more anterad than linguad, and evidently terminated below the protoconid; this condition is the basis for the reference to *Pediomys*. The hypoconid and entoconid are high and about equal in size, and the hypoconulid is close to the entoconid; all this is as described by Clemens (1966:106). There is a distinct cingulum descending from the entoconid on the posterior face of the hypoconid. The width of the talonid is 2.9 mm. This width is the same as one of the dimensions given by Clemens for the M_2 of *Pediomys ?florencae*. Probably the Henry Farm specimen belongs to the same species as the specimens referred with question to *P. florencae* by Clemens.

Order Insectivora
Family Leptictidae Gill, 1872

Genus *Gypsonictops* Simpson, 1927

Gypsonictops cf. *hypoconus* Simpson, 1927

REFERRED SPECIMEN

A deeply worn right M^1 (Fig. 5B), from about 5 m above the base of the Scollard Formation, Henry Farm locality.

DESCRIPTION

The crown is obliquely V-shaped, with the trigon reduced by wear to a broad, shallow V; there is a broad notch between the remnants of the paracone and metacone. The hypocone shelf is well developed but somewhat worn; the margin is curved, not angulate. There is a narrow but distinct cingulum on the anterior face of the crown. The anteroposterior diameter of the crown at the hypocone is 1.4 mm. The dimension is not directly comparable with those given by Lillegraven (1969:53) and Clemens (1973:16), since these authors took measurements in the paracone-metacone axis. If calculations are made from the scale of the illustrations as given by these authors, the anteroposterior diameter at the hypocone is approximately 1.4 mm for *G. hypoconus* and 1.75 mm for *G. illuminatus*. For this reason the Henry Farm specimen is compared with *G. hypoconus*. *G. hypoconus* occurs but is rare in the Griffith Farm assemblage (Lillegraven, 1969). That the extreme wear of the Henry Farm specimen is premortem is shown by its resemblance to the premortem-wear condition described by Clemens (1973:22, 23).

Phylum Mollusca
Class Pelecypoda
Family Unionidae

Genus *Plesielliptio* Russell, 1934

GENERIC CHARACTERS

Shell of medium size, narrowly to broadly ovoid. Beaks sculptured with a few fine, close-set plications, concentric or double-looped, and having two slightly divergent, straight or gently curved lines directed posteroventrad. No posterior radiating ornamentation. Type species *Unio priscus* Meek and Hayden (1856).

Plesielliptio cf. *priscus* (Meek and Hayden), 1856

REMARKS

For a full description, with illustrations, of *Plesielliptio* ("*Unio*") *priscus*, see Meek (1876:516, 517, pl. 43, fig. 8a–d). This well-known unionid appears to be represented at the Lynass Mine and Kirbyson Farm localities by portions of the shell, some of which show the umbonal markings with seven plications characteristic of the genus (Fig. 5C). Reconstruction of the shell outline indicates a broadly ovoid form, similar to that of *P. priscus*. This species is widespread in the Paleocene formations of western Canada and the adjacent United States. It has been reported from Cretaceous formations, but these occurrences need verification.

Family Sphaeriidae Jeffreys, 1862

Genus *Sphaerium* Scopoli, 1777

Sphaerium formosum (Meek and Hayden), 1856

REFERENCES

Cyclas formosa, Meek and Hayden, 1856:115
Sphaerium formosum, Meek, 1876:526, pl. 42, fig. 4a–c

SPECIFIC CHARACTERS
Shell small for the genus, moderately convex, inequilateral in outline. Beaks anteriorly placed and slightly inclined forwards. Anterior dorsal margin slightly convex and sloping; posterior margin nearly straight; ventral margin rounded, most prominent posterior to midlength. Anterior extremity rounded; posterior extremity truncated more or less obliquely. Dimensions of holotype (USNM 2125): length, 4.3 mm; height, 3.5 mm; thickness, about 2.4 mm.

REMARKS
Shells of this small, asymmetrical sphaeriid occur at the Lynass Mine locality (Fig. 5D). The species was originally described from the Fort Union Group (Sentinel Butte Formation) of North Dakota. It has a wide distribution in the Ravenscrag and Paskapoo formations. The reported occurrence in the Oldman and St Mary River formations is doubtful.

Sphaerium fowleri **Russell, 1931**

REFERENCES
Russell, 1931:11, 12, pl. 1, figs. 5–8; Tozer, 1956:43, pl. 2, fig. 6

SPECIFIC CHARACTERS
Shell medium-sized to large for the genus, moderately convex, broadly and equilaterally ovoid in outline. Beaks placed a little anterior to midlength. Dorsal margin broadly convex, nearly straight in front; ventral margin broadly convex. Extremities rounded, the anterior extremity somewhat abruptly. Cardinal teeth relatively robust, the first two close together and nearly vertical, the third sloping posteroventrad; left anterior lateral tooth rather robust. Dimensions of holotype (UA PA88): length, 11.5 mm; height, 9.3 mm; width originally, about 6 mm.

REMARKS
Shells of this species occur at Lynass Mine (Fig. 5E) and Kirbyson Farm localities in relative abundance. The species has been reported previously from the Paskapoo Formation of Alberta and the Ravenscrag Formation of Saskatchewan.

Genus *Pisidium* Pfeiffer, 1821

Pisidium squamula **Russell, 1932**

SPECIFIC CHARACTERS
Shell small, suborbicular, inequilateral, very compressed. Beaks not prominent, placed posterior to midlength. Dorsal margin short, sloping from the beak; ventral margin most prominent anterior to midlength. Lateral teeth present, the posterior one a little more prominent than the anterior; cardinal teeth obscure. Dimensions of holotype (GSC 6793): length, 4.3 mm; height, 3.8 mm.

REMARKS
Shells of this tiny clam (Fig. 5F) are relatively abundant at the Lynass Mine locality. They have the discoid shape of the type and the slightly posterior position of the beaks, as in modern species of *Pisidium*. The species has been known previously only from the St Mary River Formation on the Oldman River north of Lundbreck, Alberta.

Class Gastropoda
Family Hydrobiidae Troschel, 1857

Genus *Hydrobia* Hartmann, 1821

Hydrobia anthonyi **(Meek and Hayden), 1856**

REFERENCES
Melania Anthonyi, Meek and Hayden, 1856:124
Hydrobia Anthonyi, Meek, 1876:571, pl. 43, fig. 10a–d

SPECIFIC CHARACTERS
Shell small. Spire moderately elongate, pointed; volutions five or six, gently convex externally; last whorl rounded abruptly to base. Aperture obliquely ovoid, narrowly rounded in front and behind; inner lip a little expanded. Umbilicus slitlike. Surface marked by faint lines of growth. Dimensions of holotype (USNM 2149): length, 4.3 mm; width, 2.4 mm; length of aperture, 1.6 mm.

REMARKS
Crushed but otherwise typical specimens of this little snail (Fig. 5G) occur at the Getz Ranch locality. In outline they suggest a pupillid. The species is known from the Fort Union Group (Tongue River Formation) of Montana, the Ravenscrag Formation of Saskatchewan, and the Paskapoo Formation of Alberta.

Hydrobia warrenana **(Meek and Hayden), 1857**

REFERENCES
Melania Warrenana, Meek and Hayden, 1857:137
Hydrobia Warrenana, Meek, 1876:572, pl. 43, fig. 11a–c

SPECIFIC CHARACTERS
Shell small, slender. Spire elongate, pointed; volutions about seven, regular, gently convex or flattened exter-

nally; last whorl rounded abruptly to base. Aperture broadly and obliquely ovoid. Surface with faint lines of growth. Dimensions of holotype (USNM 2147): length, 7.1 mm; width, 3.5 mm; length of aperture, 2.5 mm.

REMARKS
Shells of this species are abundant at the Getz Ranch locality (Fig. 5H). They differ from those of *H. anthonyi* in being of slightly larger size, and having a more elongate spire and flattened sides. The geological age is similar.

Family Valvatidae Gray, 1840

Genus *Valvata* Müller, 1774

Valvata subumbilicata (Meek and Hayden), 1856

REFERENCES
Planorbis subumbilicata, Meek and Hayden, 1856:120
Valvata subumbilicata, Meek, 1876:590, pl. 43, fig. 13a–c

SPECIFIC CHARACTERS
Shell small, almost discoidal. Spire very short; volutions two and a half to three, rounded, increasing in size rapidly; suture impressed. Aperture transversely ovoid. Umbilicus deep, with diameter one-quarter to one-third width of shell. Surface marked by fine lines of growth. Holotype lost; maximum diameter of an Ardley shell-bed specimen, 3.5 mm.

REMARKS
Specimens of this small, planispiral shell are numerous at the Lynass Mine locality (Fig. 6A), rare at the Getz Ranch locality (Fig. 6B). The species is widely recognized in Paleocene formations such as those of the Fort Union Group of North Dakota and the Paskapoo of Alberta. *Valvata filosa* Whiteaves (1885:25), from the St Mary River Formation of Alberta, is very similar but, as Tozer (1956) has pointed out, in that species the body whorl is not so expanded. In this respect the Ardley specimens resemble *V. subumbilicata*.

Family Viviparidae Gray, 1847

Genus *Viviparus* Montfort, 1810

Viviparus leai (Meek and Hayden), 1856

REFERENCES
Paludina Leai, Meek and Hayden, 1856:121
Viviparus Leai, Meek, 1876:577, pl. 44, fig. 6a–d

SPECIFIC CHARACTERS
Shell medium-sized. Spire moderately elongate; volutions about five, convex; last whorl faintly flattened at the periphery and rounded abruptly to base. Aperture rather broad; inner lip slightly reflected. Umbilicus very small. Surface marked by numerous lines of growth, fine revolving striae, and in typical specimens, spiral rows of minute pits. Dimensions of holotype (USNM 2154): length, 25.0 mm; width, 20.5 mm; length of aperture, 14.0 mm.

REMARKS
Shells of this species occur at the Getz Ranch locality (Fig. 6E). It is characteristically Paleocene, ranging from the Fort Union Group of North Dakota and Montana to the Paskapoo Formation of Alberta as far north as the Swan Hills. Specimens from the St Mary River Formation, formerly referred to this species, were made the basis of a new species, *V. makowanensis*, by Tozer (1956).

Genus *Lioplacodes* Meek, 1864

Lioplacodes nebrascensis (Meek and Hayden), 1856

REFERENCES
Melania Nebrascensis, Meek and Hayden, 1856:124, 125

FIG. 5 A,B: Fossils from Henry Farm locality. C–H: Fossils from Ardley shell bed.
A. *Pediomys* cf. *florencae* Clemens, talonid of right M_1 or M_2, stereoscopic crown views, × 10.
B. *Gypsonictops* cf. *hypoconus* Simpson, incomplete and worn M^1, stereoscopic crown views, × 10.
C. *Plesielliptio* cf. *priscus* (Meek and Hayden), incomplete right valve, external view, × 4.
D. *Sphaerium formosum* (Meek and Hayden), incomplete left valve, stereoscopic internal views, × 6.
E. *Sphaerium fowleri* Russell, external mould of left valve, stereoscopic views, right and left interchanged to simulate original shell, × 2.5.
F. *Pisidium squamula* Russell, incomplete left valve, stereoscopic external views, × 6.
G. *Hydrobia anthonyi* (Meek and Hayden), stereoscopic dorsal views, × 6.
H. *Hydrobia warrenana* (Meek and Hayden), stereoscopic dorsal views, × 6.

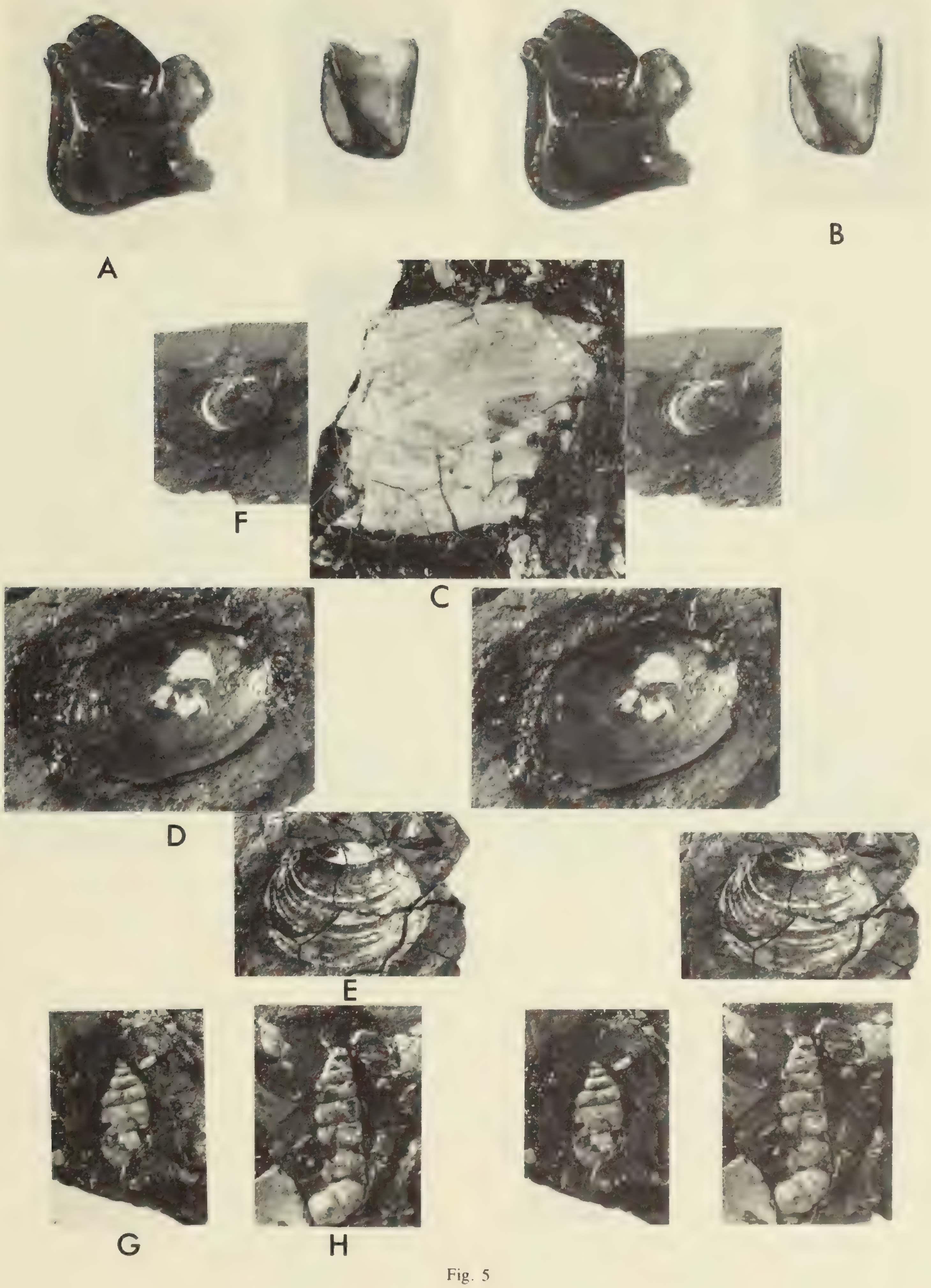

Fig. 5

Goniobasis Nebrascensis, Meek, 1876:565, 566, pl. 73, fig. 12–12h
Lioplax nebrascensis, Russell, 1931:13, 14, pl. 2, figs. 2–5
Lioplacodes nebrascensis, Yen, 1946:44; Tozer, 1956:63, 64, pl. 6, figs. 17–19

SPECIFIC CHARACTERS
Shell medium-sized for the genus. Spire moderately elongate, pointed; volutions six or seven, slightly convex externally; last two whorls somewhat prominent at midlength of whorl, with a flattened area or slight sulcus just behind. Aperture acutely angulate behind; outer lip slightly sinuous in side view; inner lip may or may not completely close umbilicus. Surface marked by numerous slightly sinuous lines of growth, fine spiral striae, and in many specimens, two or more delicate spiral ridges near midlength of each whorl. Dimensions of holotype (USNM 2138): length, 19.5 mm; width, 10.8 mm; length of aperture, 9.0 mm.

REMARKS
Crushed shells of this species are numerous at the Getz Ranch locality (Fig. 6C). It is a variable species, ranging from short shells with rounded whorls to elongate forms with a narrow shoulder on the whorls (var. *producta*). The Getz Ranch examples approach the latter in shape of shell but lack the spiral markings, even on the near-apical whorls. The species occurs in the Fort Union Group of North Dakota, the Ravenscrag Formation of Saskatchewan, and the Paskapoo Formation of Alberta. Reported occurrences in Upper Cretaceous formations are open to question.

Lioplacodes tenuicarinata (Meek and Hayden), 1857

REFERENCES
Melania tenuicarinata, Meek and Hayden, 1857:137
Goniobasis tenuicarinata, Meek, 1876:566, 567, pl. 43, fig. 14a–c
Lioplacodes tenuicarinata, Yen, 1948:41, pl. 10, fig. 7–7d; Tozer, 1856:66, 67, pl. 6, figs. 15a,b, 16a,b

SPECIFIC CHARACTERS
Shell small to medium-sized for the genus. Spire elongate, pointed; volutions six to seven, convex, flattened obliquely behind midlength of each whorl. Aperture somewhat produced in front. Surface, except for that of first two or three whorls, marked by numerous sinuous lines of growth, fine spiral striae, and three or more distinct spiral ridges on the anterior half of each whorl, most prominent at midlength of whorl and progressively less marked towards the anterior suture. Dimensions of holotype (USNM 2141): length, 13.4 mm; width, 7.4 mm; length of aperture, 5.8 mm.

REMARKS
Shells of this species occur at the Getz Ranch locality (Fig. 6D). They differ from those of *L. nebrascensis* in being small and in having the three or four spiral ridges on the whorls. This species, usually under the name of *Goniobasis tenuicarinata*, has been reported widely from the Fort Union Group and from the Paleocene formations of Saskatchewan and Alberta. It is said to occur also in the Lance and Hell Creek formations. With regard to its reported occurrences in the St Mary River and Edmonton formations, Tozer (1956) has pointed out differences in the spiral markings.

The Cretaceous-Tertiary Boundary

On the basis of the palaeontological evidence, the Cretaceous-Tertiary boundary lies within the lower Scollard beds, well above the contact with the Battle Formation but below the Ardley or No. 14 coal seam. In defining this boundary more precisely, I have taken the highest stratigraphic occurrence of dinosaurian remains as marking the approximate termination of the Cretaceous sequence. To reduce the factor of random preservation, I require the strata above this level to contain only nondinosaurian remains, such as turtle-shell fragments, champsosaur vertebrae, crocodile teeth, and mammalian bones—kinds of fossils that are known to persist across the Cretaceous-Tertiary transition. In addition, I rule out as possibly reworked any badly eroded dinosaurian remains. When these criteria are applied to the Henry Farm section (Fig. 2), the Cretaceous-Tertiary boundary appears to occur about 9 m above the base of the Scollard Formation and about 12 m above the Kneehills Tuff.

The analogous Cretaceous-Tertiary transition in eastern Montana (McCone and Garfield counties) has been under study for some years. A comprehensive account of the stratigraphy and mammalian palaeontology of this area has been published by Archibald (1982), with an addendum (1984). The evidence presented by that author on the Cretaceous-Tertiary boundary appears fully compatible with that from the Scollard Canyon and Henry Farm localities in Alberta.

In a recent paper Lerbekmo and Coulter (1985) published the results of a detailed magnetostratigraphic survey of the Edmonton formations from Scollard Canyon

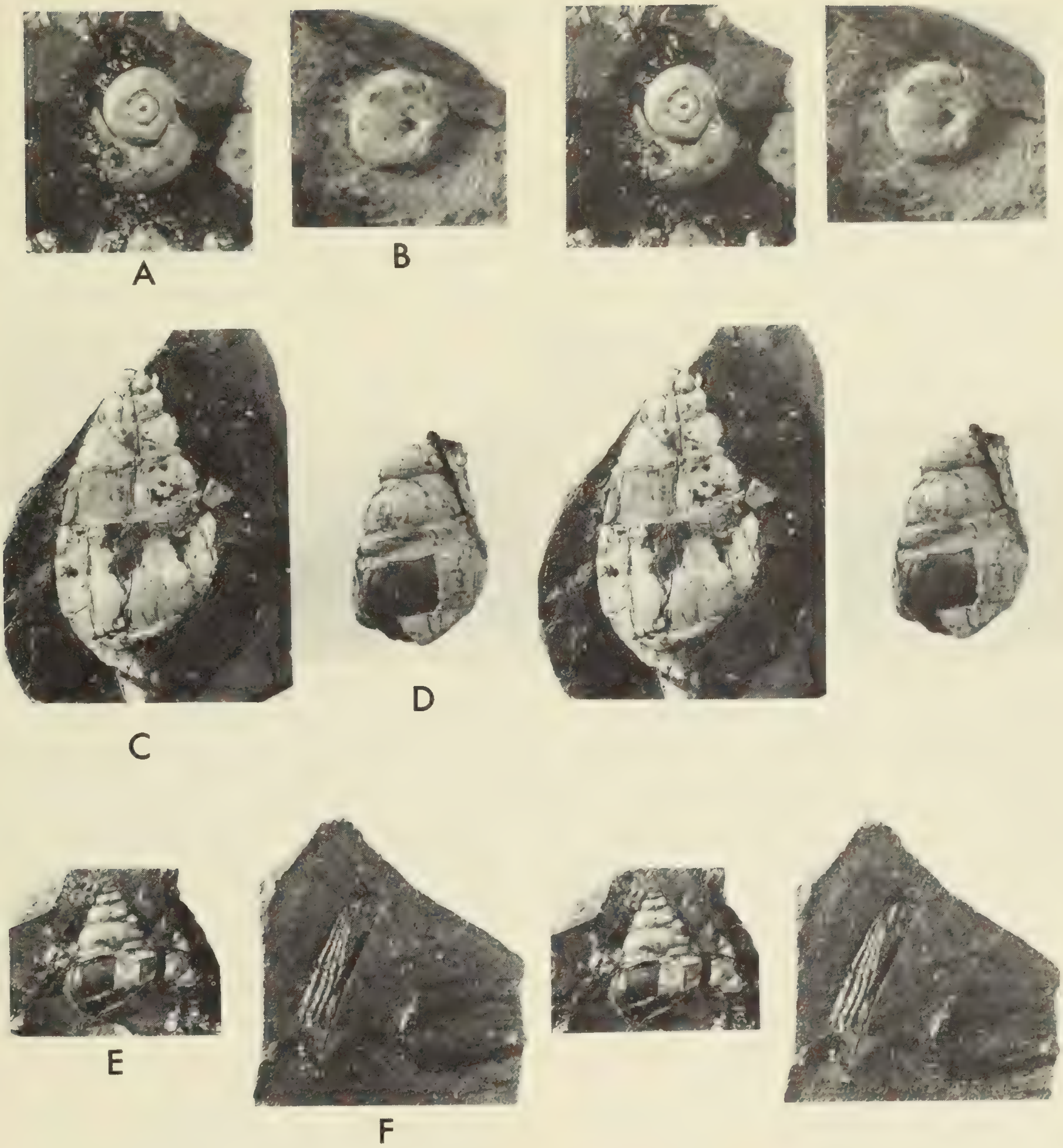

FIG. 6A–F. Fossils from Ardley shell bed.

A. *Valvata subumbilicata* (Meek and Hayden), stereoscopic apical views, × 10.

B. *Valvata subumbilicata* (Meek and Hayden), stereoscopic basal views, × 10.

C. *Lioplacodes nebrascensis* (Meek and Hayden), stereoscopic ventral views, aperture incomplete, × 2.

D. *Lioplacodes tenuicarinata* (Meek and Hayden), stereoscopic dorsal views, × 2.

E. *Viviparus leai* (Meek and Hayden), stereoscopic dorsal views of incomplete shell, × 2.

F. Unidentified fish scales, stereoscopic views, × 6.

to beyond Drumheller. This includes radiometric age determinations for the Cretaceous-Tertiary boundary and the Ardley coal seam. The boundary is placed at the base of the Nevis coal seam (No. 13), to coincide with the iridium anomaly, about 4 m above the highest known dinosaurian occurrence and 18 m below the Ardley (No. 14) coal seam (Lerbekmo and Coulter, 1985:81). These data, which were compiled from the Scollard Canyon area, are close to those published by me for the same area (Russell, 1983:1224). However, as noted above, dinosaurian remains occur at the Henry Farm locality up to 11 m below the Ardley seam, which would place them well above the stratigraphic level of the Nevis seam if it were present. Regarding the palynological evidence, Lerbekmo and Coulter (1985:81) quoted C. Singh as stating that *Aquilapollenites* extends to 0.7 m above the top of the Nevis seam. I have noted above that Norris (pers. comm., 1983) found this genus represented in my samples from the Ardley shell bed, which is about 6 m above the Ardley seam and is of Paleocene age.

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NOTE. Some of the citations in the headings of the systematic descriptions are not included among the following references: they refer to early works not actually consulted by me, but are cited to avoid nomenclatural ambiguity.

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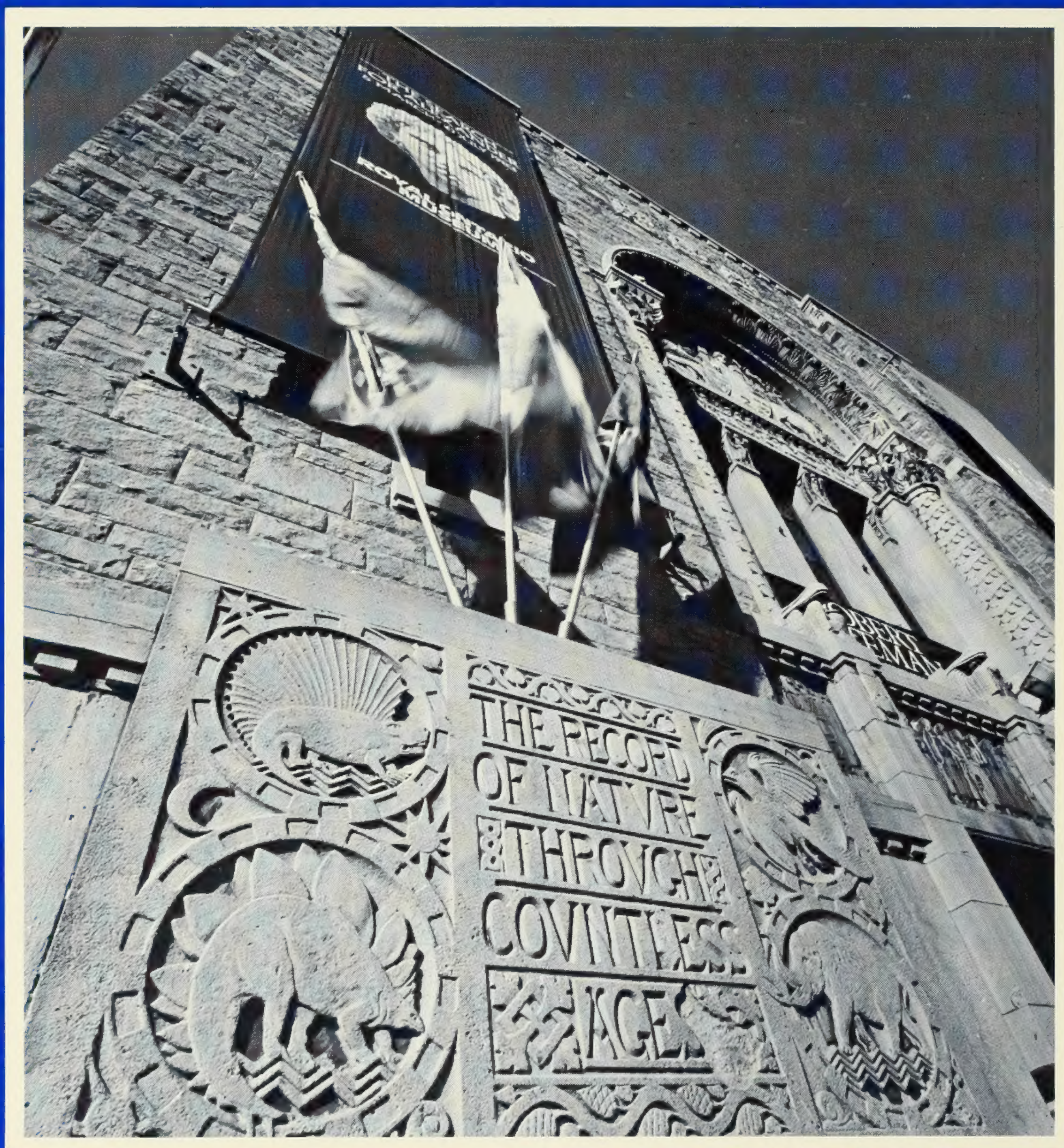

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